Rapidly tunable laser

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Inventor(s):	HALL DENIS RODERICK; LIPTON KENNETH SAMUEL
Applicant(s)::	LASER APPLIC LIMITED
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Abstract

A rapidly tunable laser producing a repeatable sequence of output frequencies comprises a dispersive element (14) within the resonant optical cavity so that only one wavelength can resonate at any instant, and an electrically controlled device (10) to vary this wavelength. In one embodiment device (10) is an an angle scanning device. As the scanning angle changes, the resonator is in alignment sequentially for wavelengths characteristic of each of a plurality of possible laser transitions. In an alternative embodiment the dispersive element is an acousto optic modulator device which is electrically controllable and may incorporate the rear reflector and grating.

Claims

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SPECIFICATION
Rapidly tunable laser
The present invention is concerned with a rapidly tunable laser.

Many lasers can be caused to operate on more than one lasing transition by the use of suitable dispersive elements such as prisms or gratings positioned within the laser resonator.

One example is the carbon dioxide laser which has many rotational-vibrational transitions in two bands in the 9- um region of the spectrum. One may select any one of these transitions by suitably aligning the dispersive element to the precise angle with respect to the optic axis which minimises cavity losses for the wavelength of the desired transition.

Small adjustments to this angle will allow the laser output to be tuned from transition to transition, such as, for example, by the use of a precise micrometer movement on well known laser mirror mounts. Such wavelength changes are of necessity very slow. However, there are applications where the ability of the laser to scan very rapidly from line to line would be a distinct advantage.

It is an object of the present invention to provide a means by which such a laser may be tuned rapidly from line to line to produce a repeatable burst of sequential transition output.

In accordance with the present invention, this is achieved by the use of an electrically controlled angle scanning device which is arranged in a laser resonator between the laser mirror and a dispersive element, such as a diffraction grating or prism, such that as the scanning angle changes, the resonator is in alignment sequentially for wavelengths characteristic of each Of a plurality of possible laser transitions.

By this means, the laser output will consist of a sequence of rapid bursts, each burst consisting of a series of lines produced sequentially as the laser output sweeps across the available gain spectrum.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:
Figures 1 and 2 are schematic diagrams of two embodiments of rapidly tunable lasers in accordance with the present invention; and
Figure 3 is a diagram showing a typical output from the laser arrangement of Fig. 1.

With reference to Fig. 1, the laser has a resonator designed to incorporate an electrically controlled angle scanning device 10 such as an electro-mechanical scanner, either of the linear or the resonant variety, or an acoustoptic deflector. Such devices are capable of scan rates of at least tens of kilohertz. This scanning device is disposed between the laser mirror 1 2 and a dispersive element 14, such as a diffraction grating or prism. The laser gain medium is indicated by the reference numeral 16.

As the scanner angle changes, the resonator will be in alignment sequentially for the wavelengths characteristic of each of the rotational vibrational transitions. Consequently, the output of the laser will consist of a sequence of pulses as illustrated in Fig. 3. Then, as the scanner reverses direction the output will be a mirror image of the first scan. In this way, bursts of radiation, each burst consisting of a series of lines produced sequentially at the laser output, sweeps across the available gain spectrum.

In the embodiment of Fig. 2, an acousto optic device 1 8 is used as the rear reflector and the grating, although these functions can be separated. A partially transmitting laser mirror 20 is disposed between the laser gain medium 16' and the modulator device 1 8.

The grating equation is:
2d sin < p = nA

where d = grating spacing
ss = incident angle
A = wavelength
By varying d and keeping < p constant, the output wavelength can be adjusted. The grating spacing can be adjusted by simply altering the input frequency to the acousto optic device 1 8. It will be noted that the relatively low reflection efficiencies achievable by using an acousto optic modulator 1 8 as a grating are counteracted by employing a three-mirror cavity.

<#s> These laser devices have many possible applications in remote surveillance such as trace gas or pollution detection or any system where a rapidly tuned frequency-agile laser is required.

CLAIMS

1. A method of rapidly tuning a laser from line to line to produce a repeatable burst of sequential transition output by arranging an electrically controlled angle scanning device in a laser resonator between the laser mirror and a dispersive element of the resonator, such that as the scanning angle changes, the resonator is in alignment sequentially for wavelengths characteristic of each of a plurality of possible laser transitions.

2. A method as claimed in claim 1 in which the output wavelength conforms to the relation nA = 2d sin ss where A is the wavelength, d is the grating spacing and < p is the incident angle, and in which the grating spacing is adjusted by altering the input frequency to an acousto optic device serving as the angle scanning device.

<#s> 3. Apparatus to perform the method of claim 1 in which the angle scanning device is an electro mechanical scanner of either the linear or resonant variety.

4. Apparatus as claimed in claim 3 in which the dispensive element is a diffraction grating or prism.

5. Apparatus to perform the method of claims 1 or 2 in which the angle scanning device is an acousto optic device.

6. Apparatus as claimed in claim 5 in which the acousto optic device is used as the rear reflector and grating of the dispersive element.

7. Apparatus as claimed in claims 5 or 6 in which a partially transmitting laser mirror is disposed between the laser gain medium and the acousto optic modulator device.

8. Apparatus as claimed in claim 6 in which the grating equation for the acousto optic modulator device is 2d sin + = nA, where d = grating spacing, < p = incident angle and A = wavelength.

<#s> 9. Apparatus as claimed in any of claims 5 to 8 in which a three-mirror cavity is employed to counteract low reflection efficiency using the acousto optic modulator device.

10. Apparatus to produce a repeatable burst of sequential transition output from a laser constructed and arranged substantially as hereinbefore described with reference to
Fig. 1 or Fig. 2 of the accompanying drawings.

11. A method of rapidly tuning a laser from line to line, substantially as hereinbefore described with reference to the accompanying drawings.

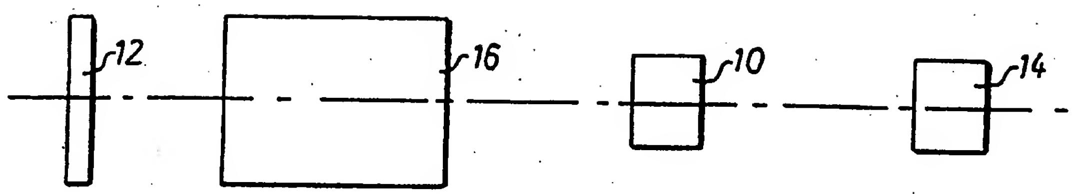

Fig 1

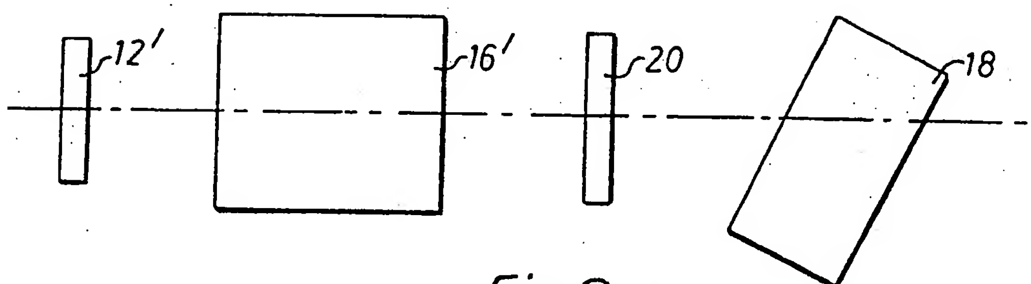

Fig 2

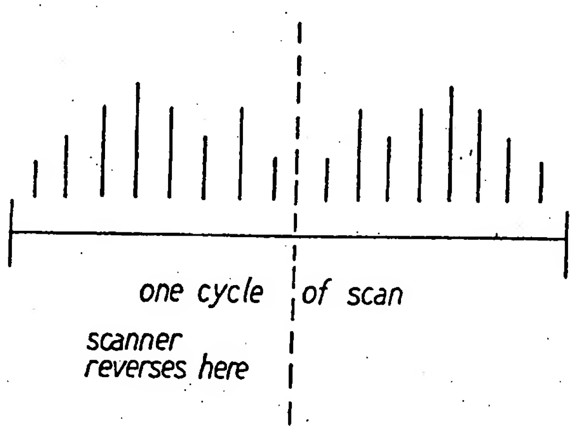

Fig 3